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**SYSTEM AND METHOD FOR RECEIVING AND TRANSMITTING  
INFORMATION IN A MULTIPATH ENVIRONMENT**

**Inventor: Timothy D. Forrester**

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**SYSTEM AND METHOD FOR RECEIVING AND TRANSMITTING  
INFORMATION IN A MULTIPATH ENVIRONMENT**

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**Field Of The Invention**

The present invention generally relates to a system and a method for receiving and transmitting information using wireless networks and, more specifically, to an antenna system and a method for receiving and transmitting information in a wireless multipath environment.

**Background Of The Invention**

A signal that is received or transmitted by a conventional wireless communications device in a wireless communications network is influenced by the surrounding environment.

In theory, a conventional wireless communications device that has a single antenna 200 would have a radiation pattern as shown in a polar plot illustrated in FIG. 3. The single antenna 200 has an isotropic radiation pattern 210 illustrated with an isotropic gain line 220 of, for example, 0 dBi. Although radiation patterns are three dimensional, it is understood that the polar plots are merely two-dimensional representations. Thus, a polar plot may represent, for example, a cross section of a three-dimensional radiation pattern. In addition, the phrase "radiation pattern" is to be defined as including at least transmission patterns or reception patterns. The isotropic radiation pattern 210 is a theoretical, ideal model occurring, for example, in the remote vacuum of space with a point source of radiation.

In practical settings, for example, in an urban environment, multipath and other considerations create nonuniformities in the radiation patterns. A signal may bounce off, for example, the ground, buildings, walls or other reflecting structures before reaching the single antenna 200 of the conventional wireless communications device. Furthermore, since a  
5 signal may be scattered simultaneously across a plurality of paths in space and time before reaching the single antenna, the signal may interfere constructively and destructively with itself. FIG. 4 shows another polar plot illustrating an example of a multipath radiation pattern 260 including a gain line 230 generated from the single antenna 200. The gain line 230 has been distorted due to multipath interference. Thus, for example, points 240, 250,  
10 although equidistant from the single antenna, effectively see different radiation patterns in which the point 240 sees greater signal gain than the point 250.

Therefore, a user of the conventional wireless communications device, that is suffering from poor reception or transmission due to multipath conditions, typically may need to physically move around in a random search for an improved signal (e.g., move from  
15 the point 250 to the point 240 without knowledge of the shape of the radiation pattern 260). Such physical translations of the conventional wireless communications device are not convenient and may not even be available under certain conditions such as, for example, when the user may not be free to move around.

In addition, since multipath effects result, in part, from constructive and destructive  
20 interference of signals, multipath effects differ at different signal frequencies. Thus, for example, as shown in a polar plot illustrated in FIG. 5, a first gain line 270 is generated by the single antenna 200 at a first frequency  $f_1$  and a second gain line 280 is generated by the

single antenna 200 at a second frequency  $f_2$ .

The conventional wireless communications device may transmit and receive signals at different frequencies. Thus, for example, via the single antenna, the conventional wireless communications device may transmit at the first frequency  $f_1$  and receive at the second frequency  $f_2$ . The conventional wireless communications device effectively experiences, for example, a radiation pattern for transmission as represented by the gain line 270 and a radiation pattern for reception as represented by the gain line 280. The consequences during, for example, two-way wireless communications between the single antenna 200 and a point 290 (e.g., a base station) are further illustrated in FIG. 5. The point 290 and the antenna 200 effectively experience disparate radiation patterns depending upon whether the single antenna 200 is transmitting or receiving. In this case, the single antenna 200 effectively experiences substantially more gain in receiving signals from the point 290 than in transmitting signals to the point 290. Thus, it is possible, for example, that although the signal from the point 290 is successfully received, the signal transmitted to the point 290 may be lost.

### Summary Of The Invention

The present invention alleviates to a great extent the disadvantages of conventional apparatus and methods for receiving and transmitting information in wireless communications system.

In a preferred embodiment, the present invention provides a system and a method for receiving and transmitting information in a multipath environment including a first antenna,

a second antenna, a switching module, a receiver module and a transmitter module. The switching module is adapted to couple the receiver module to one of the first antenna or the second antenna as a function of reception characteristics of the first antenna and the second antenna. The switching module is also adapted to couple the transmitter module to one of the first antenna or the second antenna as a function of transmission characteristics of the first antenna and the second antenna.

The present invention has an advantage in that the wireless communications device provides the first antenna and the second antenna from which the wireless communications device can select to optimize transmission characteristics or reception characteristics. The present invention has an advantage in that the wireless communications device can automatically couple the transmitting module to the antenna that provides the best transmission characteristics. The present invention also has an advantage in that the wireless communications device can automatically couple the receiving module to the antenna that provides the best reception characteristics.

These and other features and advantages of the present invention will be appreciated from review of the following detailed description of the present invention, along with the accompanying figures in which like reference numerals refer to like parts throughout.

### **Brief Description Of The Drawings**

FIG. 1 shows a schematic representation of some components of a wireless communications device according to the present invention;

FIG. 2A is an illustration of a wireless device according to the present invention;

FIG. 2B is an illustration of a wireless device according to the present invention;  
FIG. 3 shows a polar plot of an isotropic radiation pattern for a conventional antenna;  
FIG. 4 shows a polar plot of a radiation pattern in a multipath environment for a  
conventional antenna; and  
5 FIG. 5 shows a polar plot of a radiation pattern at different frequencies in a multipath  
environment for a conventional antenna.

### **Detailed Description Of The Invention**

FIG. 1 illustrates an exemplary embodiment of a wireless communications system  
10 including a wireless communications device 100 according to the present invention. The  
wireless communications device 100 may include, for example, a handheld wireless  
communications device, a mobile phone, a car phone, a cellular or a personal  
communications services (PCS) phone, a cordless phone, a laptop computer or other  
computing device with a wireless modem, a pager or a personal digital assistant (PDA). The  
15 wireless device 100 may be digital or analog or some combination thereof. Indeed, the  
present invention also contemplates other forms of wireless communications devices known  
to one of ordinary skill in the art.

The wireless communications device 100 may include, for example, a first antenna  
110, a second antenna 120, a switching module 130, a transmitter module 140, a receiver  
20 module 150 and a main controller 160. The switching module 130 may include, for example,  
a receiver switch 170 and a transmitter switch 180. The main controller 160 may include,  
for example, a mobile station modem (MSM) or other processor that is programmable. The

wireless communications device 100 may also include other components (e.g., duplexers, diplexers, amplifiers, mixers, filters, oscillators, etc.) which are known to one of ordinary skill in the art and not shown or described further herein.

Referring now to FIGS. 2A and 2B, the wireless communications device 100 is shown in one possible arrangement. In this example, the wireless communications device 100 includes two antennas: the first antenna 110 in a first orientation, and the second antenna 120 oriented in a second orientation. Preferably, the first antenna 110 will be positioned in an orthogonal relationship or in another relationship that accentuates differing gain patterns from the first antenna 110 and the second antenna 120. Also, in this example, the first antenna 110 is mounted such that the antenna extends, at least in part, outside the housing of the wireless communications device 100, while the second antenna 120 is mounted inside the housing. It will be appreciated that other antenna mounting orientations and locations may be selected to support specific applications and aesthetic considerations.

In the illustrated example, the wireless communications device 100 transmits at frequency  $f_1$  as shown in FIG. 2A and receives at frequency  $f_2$  as shown in FIG. 2B. As previously described, it is likely that each antenna 110, 120 will have a different gain line at the frequency  $f_1$  as compared to the gain line at the frequency  $f_2$ . For example, the first antenna 110 has a radiation pattern with a gain line 115 when operating at the frequency  $f_1$  as illustrated in FIG. 2A and a radiation pattern with a gain line 116 when operating at frequency  $f_2$  as illustrated in FIG. 2B. In a similar manner, the second antenna 120 has a radiation pattern with a gain line 125 when operating at frequency  $f_1$  as illustrated in FIG. 2A and a radiation pattern with a gain line 126 when operating at frequency  $f_2$  as illustrated in

FIG. 2B.

The wireless communications device 100 advantageously uses the difference in gain lines, such as, for example, between the gain line 115 and the gain line 125 or between the gain line 116 and the gain line 126, to enhance operation of the wireless communications device 100. For example, the wireless communications device 100 may determine which of the first antenna 110 or the second antenna 120 is better for transmitting or receiving a communications signal and may select the better antenna for current communications. In such a manner, more consistent signal quality may be obtained, which may, for example, reduce dropped calls, enable lower power usage, or permit faster data transmissions. Since gain lines may vary in response, for example, to movements of the wireless communications device 100 or to changes in the environment, the wireless communications device 100 may continually determine and select the better antenna. Accordingly, the wireless communications device 100 may maintain a more consistent signal quality even when moving or when operated in an active, dynamic environment.

Referring again to FIG. 1, the wireless communications device 100 is described in more detail. The main controller 160 is coupled to the transmitter module 140, the receiver module 150 and the switching module 130. The transmitter module 140 is coupled to the transmitter switch 180 of the switching module 130. Via the transmitter switch 180, the transmitter module 140 can be coupled to one of the first antenna 110 or the second antenna 120. The receiver module 150 is coupled to the receiver switch 170 of the switching module 130. Via the receiver switch 170, the receiver module 160 can be coupled to one of the first antenna 110 or the second antenna 120.



Although illustrated as being in generally in the same direction, the first antenna 110 and the second antenna 120 can be disposed at an angle to each other. For example, the first antenna 110 is preferably disposed in a direction that is approximately orthogonal to the second antenna 120. Since the orientation of an antenna affects its radiation pattern, the first antenna 110 and the second antenna 120 may have different radiation patterns. Thus, the second antenna 120 may provide an alternative radiation pattern for the wireless communications device 100.

In operation according to an exemplary embodiment, the main controller 160 receives a signal from a base station of a wireless communications network via the first antenna 110 or the second antenna 120. Based on the signal, the main controller 160 sets the transmitting module 140 to transmit, for example, at a frequency  $f_1$  and the receiving module 150 to receive at a frequency  $f_2$ . The main controller 160 can evaluate which antenna 110, 120 provides the best reception characteristics at the frequency  $f_2$  in the present environment, which may include multiple paths. The main controller 160 can also evaluate which antenna 110, 120 provides the best transmission characteristics (e.g., signal strength, clarity, bit error rate, etc.) at the frequency  $f_1$  in the present environment. The evaluations can take place periodically or aperiodically (e.g., triggered by a particular condition). Based on the evaluations, the main controller 160 can control the switching module 130 to switch the transmitter module 140 or the receiver module 150 to the appropriate antenna 110, 120.

For example, during two-way communications between the wireless communications device 100 and a base station in a wireless communications network (e.g., a two-way conversation between connected callers), the main controller 160 may determine, for

example, that for the assigned channel at frequency  $f_2$ , the first antenna 110 provides superior reception to the second antenna 120 in the present environment. Thus, the main controller 160 sends a control signal to the switching module 130 that causes the first switch 170 to couple the receiver module 150 to the first antenna 110. The main controller 160 may also  
5 determine, for example, that for the assigned channel at frequency  $f_1$ , the first antenna 110 provides superior transmission in the present environment. Thus, the main controller 160 sends a control signal to the switching module 130 that causes the second switch 180 to couple the transmitter module 140 to the first antenna 110.

In operation according to another exemplary embodiment, the receiver module 150  
10 is coupled to, for example, the first antenna 110 via the first switch 170 of the switching module 130. The main controller 160 monitors the reception characteristics of the first antenna 110. If the reception characteristics become poor (e.g., the bit error rate exceeds or is nearing an applicable error threshold), then the main controller 160 tests the reception characteristics of the second antenna 110. For example, the main controller 160 may control  
15 the switching module 130 such that the first switch 170 couples the receiver module 150 to the second antenna 120 in order to evaluate the reception characteristics of the second antenna 120. This can be accomplished relatively quickly. For example, if the reception characteristic of the second antenna 120 is evaluated based on, for example, the error bit rate of the second antenna 120, then an evaluation can be determined even on a bit-by-bit basis.

20 If the main controller 160 determines that the second antenna 120 has better reception characteristics (e.g., a lower bit error rate), then the main controller 160 may keep the receiver module 150 coupled to the second antenna 120. The main controller 160 then

monitors the reception characteristics of the second antenna 120. On the other hand, if the main controller 160 determines that the second antenna 120 does not have the better reception characteristics, then the main controller 160 may control the switching module such that the first switch maintains the coupling between the receiver module 150 and the first antenna 110.

A similar procedure may be implemented by the main controller 160 in monitoring the transmission characteristics of the antennas 110, 120. For example, the main controller 160 may monitor transmission characteristics (e.g., signal strength) via feedback from the base station. Thus, if the transmission characteristics become poor (e.g., signal strength is nearing or is below a particular strength threshold) for the antenna presently in use for transmission, for example, the second antenna 120, then the main controller 160 can test the transmission characteristics of the other antenna, for example, the first antenna 110, by coupling the transmitter module 140 to the first antenna 110. In evaluating the transmission characteristic of the antennas 110, 120, the main controller 160 may use feedback information from the base station (e.g., closed loop power control). If, in this example, the first antenna 110 has the better transmission characteristics, then the main controller 160 maintains the coupling between the transmitter module 140 and the first antenna 110. The main controller 160 then monitors the transmission characteristics of the first antenna 110. On the other hand, if the main controller 160 determines that the first antenna 110 does not have the better transmission characteristics, then the main controller 160 may control the switching module such that the second switch 180 couples the transmitter module 140 to the second antenna 120.

In another exemplary embodiment, after the main controller 160 has, for example, switched antennas from the first antenna 110 to the second antenna 120 to improve, for example, transmission characteristics, the main controller 160 can then attempt to match the reception characteristics with the new transmission characteristics. In this example, if the  
5 second antenna 120 has a transmission characteristic which includes a strength parameter of a particular quantity, then the main controller 160 tests the reception characteristics of the first antenna 110 and the second antenna 120 to evaluate which one has the reception characteristic, in particular, for this example, the strength parameter, closest to the particular quantity. The antenna 110, 120 selected does not necessarily have, for example, the largest  
10 strength parameter, but only the closest matched strength parameter.

In yet another exemplary embodiment, the main controller 160 maintains a list of base stations in range for at least one of the first antenna 110 and the second antenna 120. This list can be compiled when the wireless communications device 100 receives signals from all the base stations in range of the wireless communications device 100 during, for  
15 example, a registration process or other initial process. Furthermore, the list can be updated periodically or aperiodically (e.g., triggered by a particular condition or event). Accordingly, if the transmission characteristics of the antenna presently being used for transmission becomes poor, then the main controller 160 can test the transmission characteristics for each of the antennas with each of the base stations on the list. Based upon such tests, a switch in  
20 antenna or base station may follow. If the reception characteristics of the antenna presently being used for reception becomes poor, then the main controller 160 can test the reception characteristics for each of the antennas with each of the base stations on the list. Based upon

such tests, a switch in antenna or base station may follow.

Thus, it is seen that systems and methods for receiving and transmitting information in multipath environments are provided. One skilled in the art will appreciate that the present invention can be practiced by other than the preferred embodiments which are presented in this description for purposes of illustration and not of limitation, and the present invention is limited only by the claims that follow. It is noted that equivalents for the particular embodiments discussed in this description may practice the present invention as well.

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